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## FUEL TANK

### Reference to Related Application

5 Applicants claim priority of German patent application Serial. No. 10104511.5, filed January 31, 2001.

### Field of the Invention

10 This invention relates to a fuel tank, and more particularly to a fuel tank having a reinforcing structure with an integral stress relief feature.

### Background of the Invention

15 For safety purposes, fuel tanks must withstand forces produced by pre-determined internal and external pressure differentials, transients and stresses. This is particularly true for tanks made of plastic or high density polyethylene , HDPE. Pressure transients are typically caused by environmental temperature changes. For example, a temperature rise of the tank, or the fuel contained therein, will cause the internal tank pressure to rise and deflection or deformation of the shell of the tank to occur. Uncontrolled deformation and/or expansion of the tank must be avoided to prevent the tank shell from contacting the vehicle body, which could lead to the transmission of noise to the passenger compartment of the vehicle or to damage of the tank shell and ensuing fuel leakage. The weight of the fuel contained within the tank may also lead to a deformation of the shell contour. One method to ensure the shape integrity of the tank is to use retainer straps externally clamping the tank shell. Unfortunately, this causes an increase of the assembly and mounting labor or effort and also increases materials costs,

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all of which ultimately increases the total production costs. Moreover, such measures provide no or only limited protection against external forces or vacuum or sub-atmospheric pressure conditions inside the tank.

A further known method utilizes one or multiple kiss-off members, or  
5 reinforcing structures inside the tank. The structures typically have two opposing indentations projecting inwardly and molded into respective opposing walls of the tank. The indentations "kiss" or engage and are welded to each other at their distal ends thereby decreasing deflection of the shell and increasing the shape stability of the tank. This increases tank rigidity, however, it tends to increase the opportunity of tank wall  
10 tears causing fuel tank leaks when internal pressure within the tank is excessive or external forces exerted upon the tank are extreme.

The distal ends of the opposing indentations are engaged by a spot-like or essentially circular weld. Desirably, the engagement area serves not only as a structural feature but also would serve as a yield feature which tears upon excessive forces so that  
15 the tank wall or shell does not otherwise tear. The engagement area, however, is difficult to control and/or define in production. Experiments have shown that with this type of point-like spot weld it is very difficult to obtain the desired yield behavior, since the effective wall thickness is larger at the weld than in the surrounding region. Thus, it is observed that often it is the surrounding wall region and not the weld area that yields,  
20 resulting in leakage from the tank.

### **Summary of the Invention**

An internal reinforcing structure of a plastic fuel tank resists deformation and tearing of opposing walls of the fuel tank and provides an integral, and directionally  
25 sensitive, stress relief feature when pre-determined forces are exceeded. The stress relief

feature is contained within a fuel chamber of the fuel tank defined by the opposing walls. Each wall has an inward projecting indentation of the structure which engage one-another at their distal ends or bottom portions, preferably, via a welded plastic engagement area. The indentations have a consistent wall thickness which has a higher cross-sectional area than the stress relief feature causing the stress relief feature to tear or separate as opposed to the walls thereby assuring fuel tank integrity and avoiding fuel leakage.

Preferably, the stress relief feature includes the engagement area located between bottom portions of the opposing indentations. The weld area is preferably annular in shape and encircles a void carried between the two bottom portions. Preferably, the tear or separation of the annular engagement area begins at an opening which lies in the same imaginary plane as the weld engagement area and communicates between the void and the chamber.

Objects, features, and advantages of this invention include providing a fuel tank with a reinforcing structure capable of flexing and separating when extreme forces are exerted upon the tank so the external walls do not tear which would lead to fuel tank leakage, has a limited number of parts, and provides a relatively simple, low cost, rugged, durable, and reliable fuel tank.

## **Brief Description of the Drawings**

These and other objects, features and advantages of this invention will be apparent from the following detailed description, appended claims and accompanied drawings in which:

FIG. 1 is a partial cross section view of a fuel tank illustrating a reinforcing structure of the present invention;

FIG. 2 is a cross section of the reinforcing structure illustrating a stress relief feature, and taken along line 2-2 of FIG. 1;

FIG. 3 is a partial cross section of a blow molding tool for forming the reinforcing structure;

5 FIG. 4 is an enlarged cross section of the reinforcing structure of FIG. 1;

FIG. 5 is a second embodiment of a reinforcing structure; and

FIG. 6 is a third embodiment of a reinforcing structure.

### **Detailed Description of the Preferred Embodiments**

10 Referring in more detail to the drawings, FIG. 1 illustrates a fuel tank 10 made of a high density polyethylene (HDPE) plastic or a multi-layered plastic shell utilizing a blow molding process. The tank 10 has mutually opposed and substantially parallel walls 12, 14 having respective interior surfaces 16, 18 which substantially face one-another defining a primary fuel chamber 20 between them. Walls 12, 14 unitarily  
15 form respective deep indentations 22, 24 which project into the fuel chamber 20 toward one-another to form a support or reinforcing structure or kiss-off member 26. As best shown in FIG. 2, interior surface 16 adheres to interior surface 18 at the distal ends or bottom portions 28, 30 of the respective indentations 22, 24 via a weld thereby forming an annular engagement area 32 of a stress relief feature 33 which will yield or separate  
20 upon the exertion of excessive shear forces before wall 12 or wall 14 tear themselves. The engagement area 32 is substantially evenly annular, so that the width does not vary appreciably along its circumference. This favorably influences the yield, tearing or separation characteristics through the welded annular engagement area 32. Yielding of the weld or annular engagement area 32, instead of the walls of the fuel tank shell,

assures that the fuel tank 10 and/or permeation barriers thereof will not leak or permeate fuel vapor as a result of a vehicle accident.

The interior surfaces 16, 18 enclosed by the engagement area 32 and carried by the bottom portions 28, 30 define a substantially hollow sphere or void 34. In other words, bottom portions 28, 30 of respective indentations 22, 24 resemble minor reverse indentations or dome portions 31 projecting in an outward direction with reference to the fuel tank 10. When manufacturing a plastic fuel tank 10 made by a blow molding process, the void 34 is created by the use of tooling 35 (as best shown in FIG. 3) which subjects the walls 12, 14 to a vacuum in the direction of arrows 36, 38. The tool 35 is divided into two halves each forming one of the indentations 22, 24 and having an annular portion 39 that corresponds to the annular engagement area 32 and a semi-spherical recess 41 forming one of the domed portions 31. The vacuum assures that an essentially constant wall thickness 40 is attained in the region of the indentations 22, 24 and is dependent on the ratio of the diameter of the annular area 32 to the volume of the hollow region or spherical void 34. By controlling the height and diameter of the semi-spherical contour the essentially constant wall thickness 40 in the region of the reinforcing structure is achieved.

If the engagement area 32 were of a spot-like or solid weld, without the void 34, or if the annular engagement area 32 was too large, it is likely that the welded area engagement 32 would not yield, and instead a tear through either wall 12, 14 designated by the arrows 37, 39 in the region of the indentations 22, 24 would occur causing a fuel leak from the tank 10. To prevent this tearing, a criterium for the dimension of the annular engagement area 32 is desirable. The area of the annular engagement 32 is thus smaller than the total cross sectional area of the reinforcing structure 26, and must be smaller than a minimum cross sectional area  $A_s$  of either tank

wall 12, 14 which would otherwise represent the location of an undesired tank wall tear. Referring to FIG. 4, the tear area  $A_s$  is calculated from the inner diameter 42 of the annular engagement 32 and the minimum wall thickness 40 of either wall 12, 14 in the region of the annular engagement. The equation is as follows:

5 
$$A_s = (\pi) (\text{inner diameter } 42) (\text{minimum wall thickness } 40), \text{ or}$$
$$A_s = \pi D_{42} T_{40}$$

where  $D_{42}$  is the inner diameter 42, and  $T_{40}$  is the minimum wall thickness in the annular engagement 32 region. In a similar manner, the area of the annular engagement 32 can be calculated from its inner diameter 42 and outer diameter 44, as follows:

10 
$$\text{Area } 32 = [(\pi) / (4)] [(\text{outer diameter } 44)^2 - (\text{inner diameter } 42)^2], \text{ or}$$
$$A_{32} = (\pi / 4) (D_{44}^2 - D_{42}^2)$$

where  $D_{44}$  is the outside diameter of the annular engagement 32. Experiments have shown that a dependable yield or separation of the welded annular engagement area 32 is obtained when the engagement area 32 is not more than seventy five percent of  $A_s$ , i.e.

15  $A_{32} \leq \frac{3}{4} A_s$ . Making engagement area 32 even smaller with respect to  $A_s$  introduces a greater safety margin for the yielding of the engagement area 32.

As best illustrated in FIGS. 1 and 2, the pressure between the void 34 and the chamber 20 remains equal during the manufacturing cooling process via an opening 46 of the stress relief feature 33 which extends there between. The annular engagement

20 area 32 is therefore not a closed ring, but one interrupted by at least one opening 46. Opening 46 further supports interior cooling of the void 34 which, along with equalized pressure, leads to a constant wall thickness 40 and an increase in shape stability of the walls 12, 14 during removal of the tank 10 from the mold.

The opening 46 of the stress relief feature 33 further provides a deliberate,

25 directional, weakening of the annular engagement area 32. The opening 46 extends

radially through and is co-planar to the engagement area 32, lying in the same imaginary plane. The circumferential orientation of the opening 46 is determined theoretically or empirically and generally extends in the direction of the expected problematic internal or external forces exerted upon the tank 10 during a vehicle accident. The opening 46 thereby forms a starting point for a bust-tear through the annular area 32 when a critical force is exceeded. If multi-directional forces are expected, then more than one such opening 46 may be provided for pressure relief or propagation separation. When a force is sufficient to cause a tear through the reinforcing structure 26, acting in the direction of the pressure relief opening 46, an even tear occurs through the engagement area 32 only, and without adverse tears through the walls 12, 14, which could lead to leaks from the tank 10.

Referring to FIG. 5, a second embodiment of a reinforcing structure 26' is shown wherein the annular engagement area 32 and the opening 46 of the stress relief feature 33 of the first embodiment is replaced with a plastic stress relief bar 32' with a groove 46' providing a stress relief feature 33'. The bar 32' is engaged at both ends to respective plastic fuel tank walls 12', 14' via tear resistant welds or adhesives. The bar 32' is preferably injection molded and is placed within the plastic parison while blow molding the fuel tank and before the blow molding tooling 35' is closed. The stress relief bar 32' carries the lateral groove 46' disposed approximately at mid-section. Groove 46' provides the starting point for a bust-tear through the bar 32' when a predetermined internal or external pressure or force is exceeded. The bar 32 may have a variety of shapes in lateral cross section including circular, oval and rectangular. However, the lateral cross section of the bar 32' at the groove 46' is substantially smaller than the cross section of wall 12' or wall 14' or any indentation formed therein. Similar to the first embodiment, the lateral cross section of the bar 32' at the groove 46' is



seventy five percent or less the cross section of either indentation of wall 12' or wall 14' substantially near the respective weld of the bar 32'.

Referring to FIG. 6, a third embodiment of a reinforcing structure 26" is shown wherein the annular engagement area 32 of the first embodiment is replaced with  
5 a solid rectangular or square engagement area 32". An indentation 22" has a bottom portion or hollow protrusion 28" which, unlike the first embodiment, projects further into a fuel chamber 20" defined by a tank 10". A distal end 50 of the protrusion 28" is carried by an interior surface 16" of a wall 12" which unitarily forms the indentation 22", and is rectangular in shape and thus defines the shape of the engagement area 32" which  
10 provides the engagement to an opposing indentation 24". Indentation 24" has a consistent wall thickness which is greater than a minimum wall thickness 40" of the indentation 22" located at an acute juncture 52 disposed between the protrusion 28" and the remaining indentation 22".

Unlike the first and second embodiments, when an internal or external  
15 force is applied to the reinforcing structure 26" a tear occurs through the wall 12" at the minimum wall thickness 40" of the indentation 22". A plug or welded plate 54 engaged sealably to an exterior surface 56 of the wall 12" prevents leakage of fuel out of the tank 10". Any fuel leakage through wall 12" is contained within a secondary chamber 58 carried between the exterior surface 56 at the indentation 16" and the plug 54.

20 While the forms of the invention herein disclose constitute presently preferred embodiments, many others are possible. For instance, the fuel tank and reinforcing structure need not be plastic, but can be made of metal or any other variety of materials. Moreover, adherence of the engagement area 32 can be achieved via an adhesive in place of the weld. It is not intended herein to mention all the equivalent  
25 forms or ramifications of the invention, it is understood that the terms used herein are

